Section 5

# Global Changes in the Atmosphere

## Objectives

After this lesson, students will be able to

**E.4.5.1** Describe how human activities have damaged the ozone layer.

**E.4.5.2** Identify ways that human activities might be linked to global climate changes.

## Target Reading Skill

**Outlining** Explain that using an outline format helps students organize information by main topic, subtopic, and details.

### Answers

Outlines should have Roman numerals followed by major headings and capital letters followed by minor headings.

Global Changes in the Atmosphere

I. The thinning of the ozone layer
   A. The source of ozone
   B. The ozone hole
   C. What's being done
II. Global climate change
   A. The greenhouse effect
   B. Global warming
   C. Possible consequences
   D. The difficulty of predicting climate change

**All in One Teaching Resources**

- Transparency E36

## Preteach

### Build Background Knowledge L1

***Beneficial Ozone***

Invite volunteers to tell the class about how they got a sunburn. Ask: **What in sunlight causes a sunburn?** *(Accept all reasonable responses without comment at this time.)* Tell them that without ozone high in the atmosphere, we would not be able to go outside. They will learn why in this section.



# Global Changes in the Atmosphere

## Reading Preview

### Key Concepts

- How have human activities damaged the ozone layer?
- How might human activities be linked to global climate changes?

### Key Terms

- ozone layer
- chlorofluorocarbon
- greenhouse effect
- global warming

### Target Reading Skill

**Outlining** As you read, make an outline about global atmospheric changes that you can use for review. Use the red headings for the main ideas and the blue headings for the supporting ideas.

**Global Changes in the Atmosphere**

I. The thinning of the ozone layer
   A. The source of ozone
   B.
   C.
II. Global climate change
   A.
   B.

## Lab zone Discover Activity

### What Happens to the Beads?

1. Your teacher will give you beads that change color under certain conditions, along with two pipe cleaners and a small piece of T-shirt material.
2. Thread half of the beads on one pipe cleaner, twisting the ends together.
3. Repeat Step 2 with the remaining beads. Cover the beads on this pipe cleaner with the T-shirt fabric.
4. Take both sets of beads outdoors. After two minutes, go inside. Then remove the fabric covering. Immediately observe the two sets of beads and compare their colors.

**Think It Over**

**Developing Hypotheses** Was there any difference in color between the two sets of beads? Form a hypothesis to explain your observations.

It's the first day of vacation, and it's a perfect day for the beach. It's hot, and there's not a cloud in the sky. You've found the perfect spot to read your new book. But as you begin to read, the heat and the sound of the ocean start to make you sleepy. The next thing you know, you're waking up with your head in your book! You've been asleep for two hours! And the redness on your arms reminds you that you forgot to apply sunscreen. Ouch!

## Lab zone Discover Activity

**Skills Focus** Developing hypotheses L2

**Materials** ultraviolet-light-sensitive beads, pipe cleaners, pieces of T-shirt fabric

**Time** 20 minutes

**Tips** When students return to the classroom, ask them to make observations quickly. The beads lose color when they are no longer exposed to ultraviolet light.

**Expected Outcome** Beads covered by fabric will not change color. Beads exposed to direct sunlight (even strong light on an overcast day) will change to various colors of the visible spectrum; they will vary in intensity according to the intensity of the ultraviolet light exposure.

**Think it Over** Yes; sunlight causes the beads to change color.

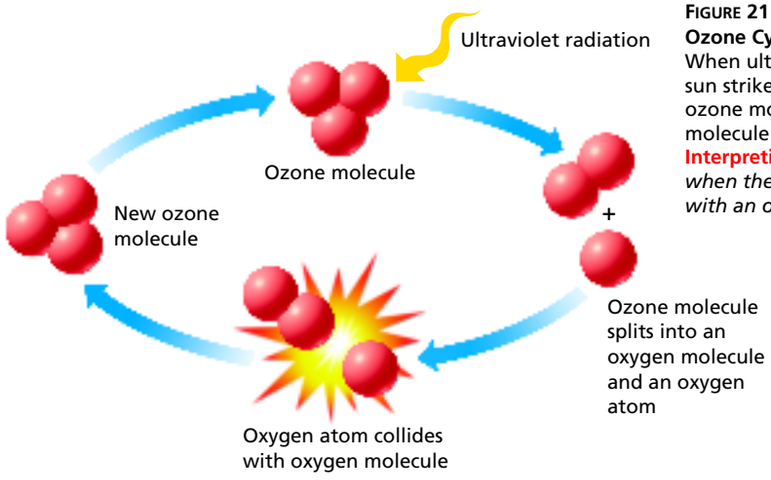



**FIGURE 21**
**Ozone Cycle**
When ultraviolet radiation from the sun strikes an ozone molecule, the ozone molecule splits into an oxygen molecule and a free oxygen atom.
**Interpreting Diagrams** *What happens when the free oxygen atom collides with an oxygen molecule?*

## The Thinning of the Ozone Layer

If you have ever had a sunburn, you have experienced the painful effects of the sun's ultraviolet radiation. But did you know that such burns would be even worse without the protection of the ozone layer? The **ozone layer** is a layer of the upper atmosphere about 30 kilometers above Earth's surface. Actually, the concentration of ozone in this layer is very low—only a few parts per million. Yet even the small amount of ozone in the ozone layer protects people from the effects of too much ultraviolet radiation. These effects include sunburn, eye diseases, and skin cancer.

Since you read earlier that ozone is a pollutant, the fact that ozone can be helpful may sound confusing. The difference between ozone as a pollutant and ozone as a helpful gas is its location. Ozone close to Earth's surface in the form of smog is harmful. Higher in the atmosphere, where people cannot breathe it, ozone protects us.

**The Source of Ozone** Ozone is constantly being made and destroyed. When sunlight strikes an ozone molecule, the energy of the ultraviolet radiation is partly absorbed. This energy causes the ozone molecule to break apart into an oxygen molecule and an oxygen atom, as shown in Figure 21. The oxygen atom soon collides with another oxygen molecule. They react to form a new ozone molecule. Each time this cycle occurs, some ultraviolet energy is absorbed. That energy does not reach Earth's surface.

**Math Skills**

### Calculating a Concentration

Levels of pollutants are often written as concentrations. A concentration is a ratio that compares the amount of one substance to the amount of another substance. For example, suppose that the concentration of ozone in part of the atmosphere is 3 parts per million. This means that there are 3 molecules of ozone in 1,000,000 molecules of air. This ratio can also be written in three other ways:

3 : 1,000,000

3 to 1,000,000

$$\frac{3}{1{,}000{,}000}$$

**Practice Problems** Express each of these concentrations in three different ways.

1. 7 parts per hundred
2. 25 parts per billion

## Differentiated Instruction

**Gifted and Talented** L3

**Researching Ozone Depletion Potential** Have students research the Ozone Depletion Potential, (ODP), a number that refers to the amount of ozone depletion caused by a substance. Tell them to plan and present an oral report that includes how the number is determined *(it is compared to the impact of a similar mass of CFC-11)* and a list of common products and their ODPs.

# Instruct

## The Thinning of the Ozone Layer

### Teach Key Concepts L2

#### *The Ozone Layer*

**Focus** Remind students that ozone is a form of oxygen that is produced when gases react in sunlight. It is toxic and helps to form smog near Earth's surface.

**Teach** Ask: **How can ozone be both harmful and beneficial?** *(It is harmful when it is close to Earth's surface where people can breathe it. It is helpful when it is higher in the atmosphere and helps to absorb ultraviolet light.)* Ask: **How does ozone protect us from ultraviolet radiation?** *(It absorbs ultraviolet radiation so that it does not reach Earth's surface.)* **What has damaged the ozone layer?** *(The use of CFCs)* **How is this damage being corrected?** *(Many countries have banned the use of CFCs.)*

**Apply** Tell students that the dramatic ozone "hole" exists only over Antarctica, but currently, the ozone layer over the United States is depleted by about 6 percent.
**learning modality: verbal**

**All in One Teaching Resources**
- Transparency E37

### Independent Practice

**All in One Teaching Resources**
- Guided Reading and Study Worksheet: *Global Changes in the Atmosphere*

**Student Edition on Audio CD**

### Monitor Progress L2

**Writing** Have each student write a paragraph to explain how ozone protects organisms on Earth. Students can save their work in their portfolios. Portfolio

**Answers**
**Figure 21** It forms a new ozone molecule.

Math Skills

**Math Skills** Ratio and proportion

**Focus** Tell students that small concentrations, such as three parts per million, are difficult to visualize.

**Teach** Give each student a sheet of graph paper ruled in tenths of an inch, and have them calculate the total number of small squares in an 8-by-10-inch block on the sheet. *(8,000)* Tell students to shade in any four squares on the sheet. Ask: **What is the concentration of black squares?** *(4 parts per 8,000)* Have volunteers write on the board the four ways to express this ratio. *(4 parts per 8,000; 4:8,000; 4 to 8,000; and 4/8,000)*

**Answers**

**1.** 7:100, 7 to 100, $\frac{7}{100}$

**2.** 25:1,000,000,000; 25 to 1,000,000,000, and $\frac{25}{1{,}000{,}000{,}000}$

Lab zone Build Inquiry L2

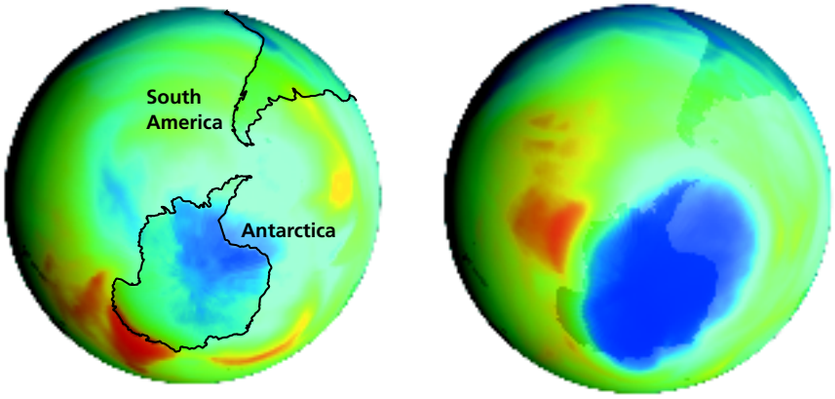
### *Modeling the Effects of CFCs on Ozone*

**Focus** Review the ozone cycle shown in Figure 21.

**Teach** Explain that when sunlight hits a CFC molecule, it releases a chlorine atom. This atom hits an ozone molecule and interrupts the normal cycle. Chlorine breaks up the ozone molecule, and it becomes regular oxygen—it never re-forms into ozone. Challenge pairs of students to create a model to demonstrate the ozone cycle and its interruption by CFCs, and then present their models to the class.

**Apply** Ask: **Why is more oxygen not helpful in blocking ultraviolet radiation?** *(Because the oxygen molecule is not the right size and shape to absorb the sun's harmful rays)* Tell students that one chlorine atom can break apart 100,000 ozone molecules.

**learning modality: kinesthetic**




▲ **1979** Scientists detect a hole in the ozone layer over Antarctica. (The bluish area represents the extent of the ozone hole.)

▲ **1986** The ozone hole has grown to cover much of Antarctica.

FIGURE 22

## Ozone Hole

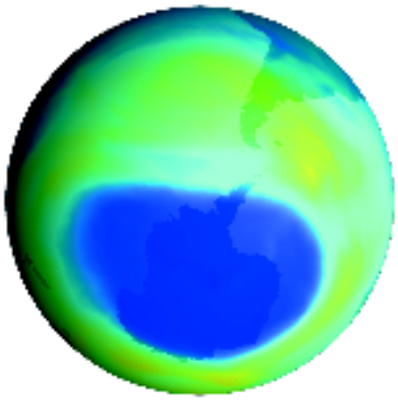
The ozone hole was first detected over Antarctica in the 1970s. The hole has generally grown since then, though it varies a bit from year to year. In each of the globes, the blue area indicates the extent of the ozone hole in the spring of that year.

**Observing** *How would you describe the change in the ozone hole from 1979 to 2000?*

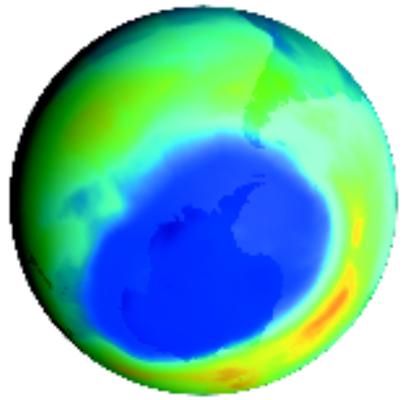
**The Ozone Hole** In the late 1970s, scientists observed that the ozone layer over Antarctica was growing thinner each spring. The amount of ozone in the ozone layer was decreasing, causing an area of severe ozone depletion, or an ozone hole. In Figure 22, you can see the size of the ozone hole in four selected years. In 2000, the hole was the largest ever, and in 2003, it was the second-largest ever.

What is to blame for the ozone hole? **Scientists determined that the major cause of the ozone hole is a group of gases called CFCs, which were used in many household products.** CFCs, or **chlorofluorocarbons,** are human-made gases that contain chlorine and fluorine. CFCs had been used in air conditioners, aerosol spray cans, and other products. High in the atmosphere, CFCs react with ozone molecules. The CFCs block the cycle in which ozone molecules absorb ultraviolet radiation. As a result, more ultraviolet light reaches Earth's surface.

**What's Being Done** In 1990, many nations signed an agreement to eventually ban the use of ozone-depleting substances, including CFCs. Most uses of CFCs were banned in 2000. Some uses of CFCs are still allowed, but compared to the 1970s, few CFCs now enter the atmosphere. Unfortunately, CFC molecules remain in the atmosphere for a long time. But scientists predict that if the ban on ozone-depleting substances is maintained, the ozone layer will gradually recover.



▲ **1993**
The ozone hole covers nearly all of Antarctica.



▲ **2000**
The ozone hole covers Antarctica and extends north over the tip of South America.

When scientists discovered that CFCs were harming the atmosphere, they immediately began to search for substitutes. Refrigerators and air conditioners were redesigned to use less harmful substances. Most spray cans were either replaced by pump sprays or redesigned to use other gases. Researchers developed new ways to make products such as plastic foam without using CFCs. As a result of this research and invention, far fewer CFCs now enter the atmosphere.

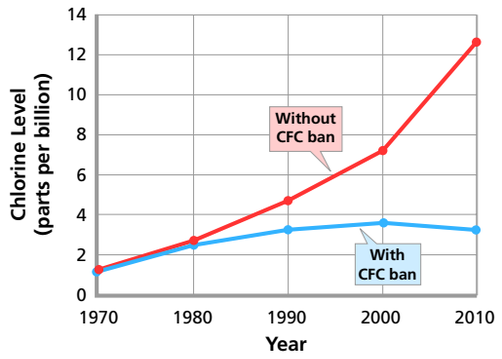
Reading Checkpoint **What do scientists predict will happen if the ban on CFCs is maintained?**

## Math Analyzing Data

### Chlorine Levels

The line graph shows a scientist's measurements and predictions of how the ban on CFCs might affect chlorine levels in the atmosphere. The red line shows the levels of chlorine without the ban on CFCs. The blue line shows the levels with the ban on CFCs.

**Chlorine Levels in the Atmosphere, 1970–2010**




1. **Reading Graphs** What variable is plotted on the horizontal axis? What variable is plotted on the vertical axis?
2. **Interpreting Data** Which graphed line shows rising levels of chlorine? What trend does the other line show?
3. **Inferring** Why do the two lines start at the same point?
4. **Drawing Conclusions** How does the relationship between the two lines change?

## Math Analyzing Data

**Math Skill** Making and interpreting graphs

**Focus** Ask a volunteer to identify the type of graph shown. *(Line graph)*

**Teach** Explain that line graphs are used to show how something has changed over time. Ask: **Why was a line graph used to represent this data?** *(To show how chlorine levels in the atmosphere have changed over time)* Tell students that line graphs can also be used to compare data. Ask: **What data does this graph compare?** *(Chlorine levels with the ban and without the ban)*

**Answers**

**1.** Year; chlorine level
**2.** The red line; the blue line shows gradually diminishing chlorine levels.
**3.** The ban did not exist in 1985, so predictions of the levels without the ban could not be made before then.
**4.** The difference in chlorine levels becomes greater over time.

## Monitor Progress L2

**Writing** Have students write a brief paragraph explaining how CFCs harm the atmosphere.

**Answers**

**Figure 22** It is getting larger.

Reading Checkpoint Scientists predict that the ozone hole will slowly recover.

# Global Climate Change

## Teach Key Concepts L2

### *Greenhouse Effect And Global Warming*

**Focus** Remind students that when sunlight hits objects on Earth, its light energy is transformed into thermal energy.

**Teach** Point out that although light energy can travel through Earth's atmosphere, some thermal energy is blocked by gases in the air, producing the greenhouse effect. Ask: **Is the greenhouse effect harmful?** *(No; without the greenhouse effect the Earth would not be warm enough to support life.)* **How is the greenhouse effect related to global warming?** *(Rising levels of carbon dioxide may intensify the greenhouse effect and cause temperatures on Earth to rise.)* **Do scientists know for certain that burning coal and oil is causing global warming?** *(No; natural factors also can cause climate change.)*

**Apply** Ask students to hypothesize how rising sea levels and warmer temperatures might affect where people live. *(Possible answer: People would have to move inland and farther from the equator.)* **learning modality: logical/mathematical**

**All in One Teaching Resources**

- Transparency E38

Go Online NSTA SciLinks

**For:** Links on changes in climate
**Visit:** www.SciLinks.org
**Web Code:** scn-0545

Download a worksheet that will guide students' review of Internet resources on changes in climate.

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# Global Climate Change

Some changes to the atmosphere could affect the climate of the whole planet. To understand why, you need to know more about the atmosphere.

**The Greenhouse Effect** Think about the sun shining through a window on a cool day. The window lets light enter the room. The light strikes objects in the room and is converted to heat. The closed windows then trap the warm air inside, and the room becomes warmer.

In the atmosphere, water vapor, carbon dioxide, and certain other gases act like windows. These gases allow sunlight to reach Earth's surface, but they prevent some of the heat from escaping into space. The trapping of heat near Earth's surface is called the **greenhouse effect.** Without the greenhouse effect, Earth would be much colder—about 33 Celsius degrees colder, on average. All of Earth's water would be frozen!

**Global Warming** Since the 1800s, coal and oil have been the main sources of energy in many parts of the world. As you have read, burning these substances produces carbon dioxide. As a result, the amount of carbon dioxide in the atmosphere has increased from 280 parts per million to 350 parts per million. This amount is increasing more quickly every year.

**Human activities that increase carbon dioxide levels may be intensifying the greenhouse effect.** One theory, called **global warming,** predicts that the increase in carbon dioxide levels will cause the average temperature to continue to rise. Scientists have estimated that in this century, the average global temperature could rise by as much as 3.5 Celsius degrees.

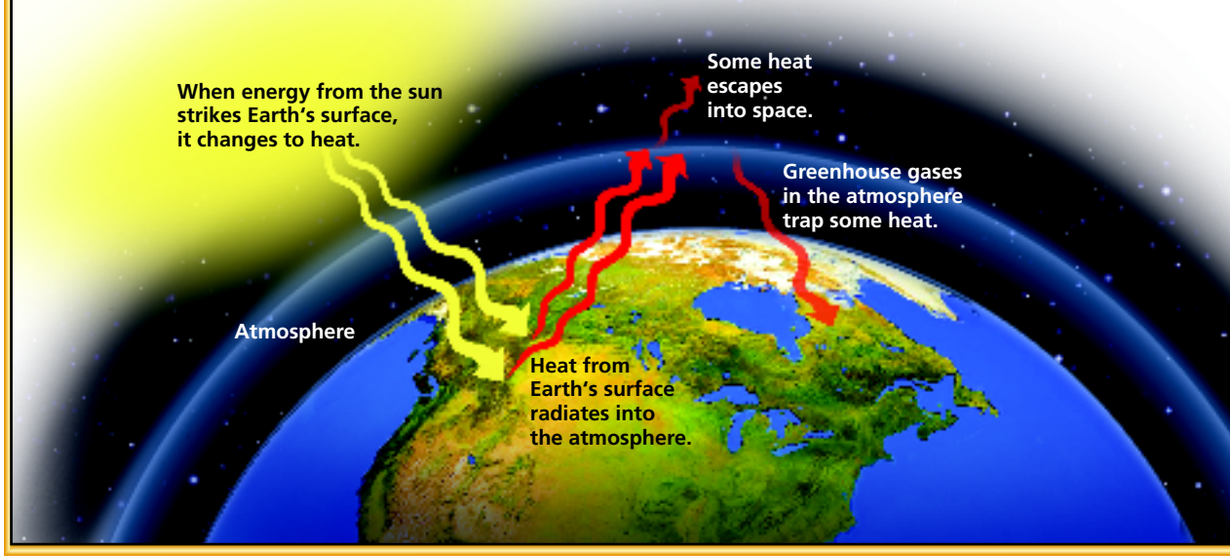


**FIGURE 23**
**Greenhouse Effect**
When energy in the form of sunlight strikes Earth's surface, it changes to heat. Certain gases in the atmosphere trap some of the heat, preventing it from escaping back into space. This trapping of heat is known as the greenhouse effect. **Applying Concepts** *What gases in the atmosphere trap heat near Earth's surface?*

## Differentiated Instruction

**English Learners/Beginning L1**
**Vocabulary: Link to Visual** Explain the greenhouse effect by using Figure 23. Explain that the yellow arrows represent light energy from the sun, and the red arrows represent thermal energy. Point to the captions and read them aloud. Then have students tell in their own words what is happening in the picture. **learning modality: visual**

**English Learners/Intermediate L2**
**Vocabulary: Link to Visual** Repeat the procedure for Beginning students, but have students write their own captions for the picture. **learning modality: visual**

**Possible Consequences** Although the predicted increase in temperature may not sound like a big change, it could have a huge impact. Parts of the Antarctic ice cap would melt, raising the level of the oceans and causing increased flooding. The temperature change would affect climate patterns all over the world. This change would, in turn, affect where crops could be grown. There might also be more hurricanes and other severe storms.

**The Difficulty of Predicting Climate Change** It is difficult to predict how Earth's climate will be affected by changes in the atmosphere. The systems that determine climate are very complex. For example, Earth's oceans, forests, clouds, and volcanoes all affect carbon dioxide levels in the atmosphere. It is difficult to know what impact each of these factors might have on climate change.

Scientists have studied climate systems for less than a century, a very short time to understand processes that can take thousands of years. Most scientists base their global climate predictions on computer models. But only time will tell if their long-range predictions have been accurate.

Reading Checkpoint **What might be three consequences of global warming?**

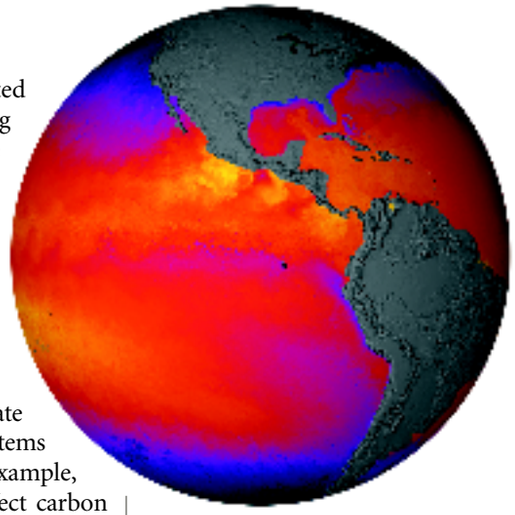

FIGURE 24
**Predicting Climate Change**
This computer-generated image of Earth shows ocean temperatures near North and South America. The lightest colors indicate the warmest temperatures. The darkest colors indicate the coolest temperatures. Images like this can help scientists predict climate change.

## Section 5 Assessment

**Target Reading Skill** **Outlining** Use the information in your outline about global atmospheric changes to help you answer the questions below.

### Reviewing Key Concepts

1. a. **Reviewing** How have human activities affected the ozone layer?
   b. **Relating Cause and Effect** What part of the ozone cycle do CFCs interrupt? What effect does this have?
   c. **Predicting** Exposure to ultraviolet radiation can cause skin cancer. How would you expect the thinning of the ozone layer to affect skin cancer rates? Explain.
2. a. **Identifying** What human activities have led to increased levels of carbon dioxide in the atmosphere?
   b. **Explaining** Explain how increased carbon dioxide levels could be linked to global climate changes.
   c. **Problem Solving** What are some steps people could take to reduce the amount of carbon dioxide that enters the atmosphere?

**Math Practice**

3. **Calculating a Concentration** Draw a picture to show what is meant by each of the following concentrations. Then express each concentration in three different ways.
   a. 4 parts per 10
   b. 19 parts per 100
   c. 7 to 10
   d. 27 : 100

## Monitor Progress L2

**Answers**

**Figure 23** Water vapor, carbon dioxide, and certain other gases

Reading Checkpoint Parts of the Antarctic ice cap would melt, causing flooding; climate patterns would change; and more hurricanes and severe storms might occur.

## Assess

### Reviewing Key Concepts

**1. a.** Human-made gases called CFCs have reduced the amount of ozone in the atmosphere, causing the ozone layer to become thinner. **b.** CFCs block the part of the cycle in which ozone molecules absorb ultraviolet light. Because the ultraviolet light is not absorbed, more of it reaches Earth's surface. **c.** The rates would increase because people would be exposed to more ultraviolet radiation.
**2. a.** The burning of coal and oil for fuel
**b.** Increased carbon dioxide in the atmosphere intensifies the greenhouse effect, causing global temperatures to rise.
**c.** Lessen our reliance on coal and oil by riding a bicycle, walking, using public transportation, and developing alternative fuels.

### Reteach L1

Use Figure 23 to review the greenhouse effect. Emphasize that heat gets trapped because, unlike light energy, it cannot move through some materials in the atmosphere.

### Performance Assessment L2

**Drawing** Have each student draw and label a diagram of the ozone cycle or the greenhouse effect.

### All in One Teaching Resources

- Section Summary: *Global Changes in the Atmosphere*
- Review and Reinforce: *Global Changes in the Atmosphere*
- Enrich: *Global Changes in the Atmosphere*

**Math Practice**

**Math Skill** Concentration

**Answers**

**a.** Circle divided into 10 wedges, 4 are colored in; 4/10, 4:10, 4 to 10
**b.** Large square divided into 100 squares, 19 are colored in; 19/100, 19:100, 19 to 100
**c.** Circle divided into 10 wedges, 7 are colored in; 7/10, 7:10, 7 parts per 10
**d.** Large square divided into 100 squares, 27 are colored in; 27/100, 27 to 100, 27 parts per 100